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Design of prestressed concrete precast pedestrian bridges by heuristic optimization. (English)

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Summary: This paper deals with the economic optimization of prestressed concrete precast pedestrian bridges typically used in public works construction. These bridges are made of a precast concrete beam that integrates an upper reinforced concrete slab for the pedestrian traffic. The beam has a U-shape cross-section. Typical span lengths range from 20 to 40 m and the width ranges from 3.00 to 6.00 m. The study shows the efficiency of heuristic optimization by the simulated annealing (SA) and the threshold accepting (TA) algorithms. The evaluation of solutions follows the Spanish code for structural concrete. Stress resultants and envelopes of these structures are computed by direct calculation. Design loads are in accordance to the national IAP code for road bridges. The algorithms are applied to a typical pedestrian bridge of 40 m of span length and 6.00 m of width. This example has 59 discrete design variables for the geometry of the beam and the slab, materials in the two elements and active and passive reinforcement. The evaluation module includes the limit states that are commonly checked in design: flexure, shear, deflections, etc. The application of the SA and TA algorithms requires the calibration of the initial temperature and threshold, the number of variables modified in each iteration, the length of the Markov chains and the reducing coefficient. Each heuristic is run nine times so as to obtain statistical information about the minimum, average and deviation of the results. Best result has a cost of 38,317 EUR for the SA algorithm and 38,713 EUR for the TA algorithm. Finally, solutions and run times indicate that heuristic optimization is a forthcoming option for the design of real prestressed structures.

MSC:

74P10 Optimization of other properties in solid mechanics
74S30 Other numerical methods in solid mechanics (MSC2010)

Keywords:

economic optimization; heuristics; prestressed concrete structures; structural design; precast beams; simulated annealing

Software:

Tabu search

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References:

[1] British Standards. BS 8110-1: 1997 structural use of concrete. Part 1: code of practice for design and construction. London: British Standards; 1997.

[2] Cohn, M. Z.; Dinovitzer, A. S.: Application of structural optimization, ASCE J struct eng 120, No. 2, 617-649 (1994)

[3] Hernández, S.; Fontan, A.: Practical applications of design optimization, (2002)

[4] Fletcher, R.: Practical methods of optimization, (2001) · Zbl 0988.65043

[5] Jones, M. T.: Artificial intelligence application programming, (2003)

[6] Holland, J. H.: Adaptation in natural and artificial systems, (1975) · Zbl 0317.68006

[7] Goldberg, D. E.: Genetic algorithms in search, optimization and machine learning, (1989) · Zbl 0721.68056

[8] Glover, F.; Laguna, M.: Tabu search, (1997) · Zbl 0930.90083

[9] Yepes, V.; Medina, J. R.: Economic heuristic optimization for the heterogeneous fleet VRPHESTW, ASCE J transport eng 132, No. 4, 303-311 (2006)

[10] Jenkins, W. M.: Plane frame optimum design environment based on genetic algorithm, ASCE J struct eng 118, No. 11, 3103-3112 (1992)

[11] Rajeev, S.; Krisnamoorthy, C. S.: Discrete optimization of structures using genetic algorithms, ASCE J struct eng 118, No.

5, 1233-1250 (1992)

[12] Coello, C. A.; Christiansen, A. D.; Santos, F.: A simple genetic algorithm for the design of reinforced concrete beams, Eng comput 13, 185-196 (1997)

[13] Rajeev, S.; Krisnamoorthy, C. S.: Genetic algorithm-based methodology for design optimization of reinforced concrete frames, Comput-aided civil infrastruct eng 13, 63-74 (1998)

[14] Koumousis, V. K.; Arsenis, S. J.: Genetic algorithms in optimal design of reinforced concrete members, Comput-aided civil infrastruct eng 13, 43-52 (1998)

[15] Hrstka, O.; Kucerova, A.; Leps, M.; Zeman, J.: A competitive comparison of different types of evolutionary algorithms, Comput struct 81, 1979-1990 (2003)

[16] Leps, M.; Sejnoha, M.: New approach to optimization of reinforced concrete beams, Comput struct 81, 1957-1966 (2003)

[17] Lee, C.; Ahn, J.: Flexural design reinforced concrete frames by genetic algorithm, ASCE J struct eng 129, No. 6, 762-774 (2003)

[18] Camp, C. V.; Pezeshk, S.; Hansson, H.: Flexural design reinforced concrete frames using a genetic algorithm, ASCE J struct eng 129, No. 1, 105-115 (2003)

[19] Sahab, M. G.; Ashour, A. F.; Toporov, V. V.: Cost optimisation of reinforced concrete flat slab buildings, Eng struct 27, 313-322 (2005)

[20] Govindaraj, V.; Ramasamy, J. V.: Optimum detailed design of reinforced concrete continuous beams using genetic algorithms, Comput struct 84, 34-48 (2005)

[21] Gonzalez-Vidosa F, Yepes V, Alcala J, Carrera M, Perea C. Simulated annealing optimization of walls, portal and box reinforced concrete road structures. In: Proceedings of the ninth international conference on computer aided optimum design in engineering (OPTI-2005), Skiathos, Greece; 2005. p. 175 – 86.

[22] Carbonell A, Martínez FJ, Yepes V, Hospitaler A, González-Vidosa F. Threshold accepting optimization of road vaults and rectangular hollow bridge piers. In: Proceedings of the 10th international conference on computer aided optimum design in engineering (OPTI-2007), Myrtle Beach, South Carolina, USA; 2007. p. 141 – 50.

[23] Yepes, V.; Alcalá, J.; Perea, C.; González-Vidosa, F.: A parametric study of optimum Earth retaining walls by simulated annealing, Eng struct 30, No. 3, 821-830 (2008)

[24] Perea, C.; Alcalá, J.; Yepes, V.; González-Vidosa, F.; Hospitaler, A.: Design of reinforced concrete Bridge frames by heuristic optimization, Adv eng softw 39, No. 8, 676-688 (2008)

[25] Payá, I.; Yepes, V.; González-Vidosa, F.; Hospitaler, A.: Multiobjective optimization of reinforced concrete building frames by simulated annealing, Comput-aided civil infrastruct eng 23, No. 8, 575-589 (2008)

[26] Payá-Zaforteza, I.; Yepes, V.; Hospitaler, A.; González-Vidosa, F.: CO2 efficient design of reinforced concrete building frames, Eng struct 31, No. 7, 1501-1508 (2009)

[27] Fomento, M.: IAP-98. Code about the actions to be considered for the design of road bridges, (1998)

[28] Fomento, M.: EHE. code of structural concrete, (1998)

[29] Kirkpatrick, S.; Gelatt, C. D.; Vecchi, M. P.: Optimization by simulated annealing, Science 220, No. 4598, 671-680 (1983) · Zbl 1225.90162 · doi:10.1126/science.220.4598.671

[30] Medina, J. R.: Estimation of incident and reflected waves using simulated annealing, ASCE J waterway port coast ocean eng 127, No. 4, 213-221 (2001)

[31] Dueck, G.; Scheuer, T.: Threshold accepting: a general purpose optimization algorithm superior to simulated annealing, J comput phys 90, 161-175 (1990) · Zbl 0707.65039 · doi:10.1016/0021-9991(90)90201-B